STATION PAPER NO. 79
FEBRUARY 1960

THE FOREST INSECT and DISEASE SITUATION, LAKE STATES, 1959

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FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE

Foreword

Forest insects and diseases are ever-present threats to Lake States timber resources. Past losses in tree growth and mortality are indicative of how destructive such pests have been and may continue to be in the years ahead. To appraise adequately the regionwide insect and disease situation, the Lake States Forest Experiment Station summarizes each year the information on the current status of insect infestations and disease infections.

To prepare such a report it is essential that use be made of all available information. Many individuals, State organizations, and forest industries have been helpful. Their active and willing cooperation is gratefully acknowledged. Special acknowledgment is made of the information and help given by the following.

Michigan:

Division of Forestry, Conservation Department
Bureau of Plant Industry, Department of Agriculture
University of Michigan
Michigan State University

Minnesota:

Division of Forestry, Conservation Department
Office of State Entomologist, Department of Agriculture
University of Minnesota

Wisconsin:

Forest Management Division, Conservation Department
Office of State Entomologist, Department of Agriculture
University of Wisconsin

Copies of the report may be obtained from the Lake States Station, who collected some of the original material, summarized all information, and processed the report.

Cover picture: Lower left, a pine-oak rust gall on jack pine.

Upper right, pine root collar weevil, a primary pest of pine plantations.

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LAKE STATES, 1959

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Station Paper No. 79
February 1960

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1/ Maintained at St. Paul 1, Minn., in cooperation with the University of Minnesota.

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Introduction

Insects and diseases play an important part in the reduction of our vast forest resource. Each year they cause large losses in timber growth and result in tree mortality. But that is not all: These agents attack the forest from seed to finished product. Stocking levels are lowered, growth is retarded, and trees are deformed, thus reducing both quality and quantity of forest products. The protection of our forests against these destructive agents is the responsibility of everyone concerned with the national economy.

This report summarizes the information collected by many agencies and individuals on the forest insect and disease situation during 1959 in the Lake States. The most important aspects are presented briefly in the next few pages. For more detailed discussion see sections on The More Important Forest Insects (or Diseases).

Highlights of 1959

For Insects

A constant watch must be kept for insect infestations in the ever-growing acreages of coniferous plantations in the Lake States. These young trees with their regular spacing and fairly even height are especially vulnerable to attack. The following insect pests in plantations during 1959 are worthy of special mention.

The white-pine weevil is still causing extensive damage throughout the region despite efforts to prevent losses through management and control.

The European pine shoot moth was temporarily reduced in numbers in some areas because of unusually cold weather. Populations are rising again and pose a threat to many red pine plantings.

The Saratoga spittlebug requires annual chemical treatment of thousands of acres to prevent tree killing and deformity.

The red-headed pine sawfly threatens all pine plantings throughout the region. The Michigan Department of Conservation sprayed 2,495 acres for control of this insect.

White grubs are frequently overlooked because of the difficulty in observing direct damage. Many thousands of seedlings are killed each year, and thousands of acres of plantings require chemical protection.

In natural stands attention has been focused for several years on four defoliators that have been in outbreak status in various parts of the Lake States.

The spruce budworm: No apparent decrease in the intensity of the current outbreak in northeastern Minnesota has been detected. All evidence to date indicates an increase in both intensity and area of defoliation in 1960.

The forest tent caterpillar: A general collapse of populations of this pest was noted in all areas checked in the region.

The jack-pine budworm: Abrupt population fluctuations of this insect are common. In local areas high populations persist for 2 years or more, and top killing and tree mortality result.

The larch sawfly: Growth studies on several areas of tamarack indicate very low increments due primarily to the feeding by the larch sawfly. As the outbreak continues, increased tree mortality is expected.

Among other insects that may develop into serious threats in this region are the following:

The Zimmerman pine moth is assuming more importance as detection becomes more complete. New shoots are being destroyed on many Christmas tree plantations. Normally tree mortality does not occur on large trees.

A pine tip moth, Rhyacionia adana, was first noted with concern in Michigan this past year although it has probably been present many years. This is primarily a pest of trees under 3 feet in height.

Hardwood defoliators have been given little consideration in the past. Information compiled by workers in Wisconsin indicates that these insects play an important part in the so-called maple blight complex.

Trends in the advance or decline of a forest disease can be determined only over a period of several years, and the fluctuations of any one year are not to be regarded as of great importance in indicating a future trend. Annual observations, however, are helpful to researchers in pointing out threatening situations and to forest owners and managers in providing guides on where controls may be needed.

In 1959 changes in distribution and severity were noted on several important diseases:

The maple blight situation appears improved, with many of the less seriously affected trees apparently recovering. Some trees died, however, and blight symptoms were found in three additional small areas in Ashland County, Wis.

Oak wilt in the Lake States showed a lower rate of spread than in previous years. It is not known if this trend will continue.

Hypoxylon canker on aspen was less prevalent in Minnesota during the year. Continued observations indicate a cyclic fluctuation in the level of infection of this disease.

Root rots of black spruce and red pine continue to plague many nurseries in the region. This problem was reported in one more nursery in 1959. Plans have been made to treat areas in at least one nursery with methyl bromide next year.

Dutch elm disease continues to spread in Michigan and Wisconsin. Thus far it has not been found in Minnesota, but each year brings it closer.

Stalactiform rust canker on jack pine was found in the Upper Peninsula of Michigan. This disease was first reported east of the Great Plains 2 years ago when it was discovered in Minnesota.

White pine blister rust "flags" were observed in abnormally large numbers early in the season in several areas of the region.

Maple dieback is widespread throughout the region. It continues as a serious threat to the northern hardwood industry. Little work has been done toward determining the cause of this problem.

In southeastern South Dakota two new problems affecting hardwoods were noted:

A general decline and mortality of elm was reported early in the summer. This condition is quite prevalent in some areas.

A group of dead and dying oaks was observed. The cause of this condition has not been determined.

The More Important Forest Insect Developments

The status of the major forest insect pests in the Lake States during the past year is outlined in the following pages. Species of less importance are mentioned but not discussed in detail.

Spruce Budworm-- Populations Continue to Rise

Populations of the spruce budworm (Choristoneura fumiferana) increased substantially in northern Minnesota in 1959 as they have each year since the pest was detected in 1954. Approximately 1,000,000 acres were moderately to severely defoliated in 1959. The overall change from the situation as it was noted in 1958 is twofold. First, defoliation is appearing farther south and is now noticeable in the extensive spruce-fir stands of the Isabella area. Secondly, the heavy defoliation for several years along the border country has caused rather extensive top killing and tree mortality on approximately 60,000 acres of spruce-fir type.

An aerial application of DDT was applied to about 7,200 acres of spruce-fir east of International Falls, Minn. This was a joint undertaking by the Minnesota and Ontario Paper Company and State and Federal agencies. Postcontrol checks indicated good control. No further control efforts in this area are contemplated at this time.

The National Forest Administration has proposed aerial control on about 20,000 acres of spruce-fir on the Superior National Forest. The greater part of this acreage is in timber areas where harvest must be delayed for 2 or more years because access roads have not been built. The objective

of the operation is to keep the timber alive and healthy until roads and markets allow harvesting. Also proposed for treatment are 10 campsite areas. On some of these the balsam and spruce have been severely defoliated, and extensive tree mortality is anticipated if the insect is not controlled.

Jack-Pine Budworm--Great Fluctuations

The jack-pine budworm (Choristoneura pinus) populations varied greatly throughout the region during 1959. Michigan reported a general decline except in portions of the Upper Michigan National Forest; harvest operations in the Forest, however, are expected to reduce this threat.

Budworm numbers appear to be increasing in northwestern Wisconsin, according to checks made by State personnel. Washburn, Douglas, and Bayfield Counties had the highest populations. This is in the general area of the outbreak sustained from 1954 through 1957.

Exceptionally high populations on a valuable jack pine stand near Cass Lake on the Chippewa National Forest necessitated chemical treatment on about 600 acres. Control was very satisfactory. Postcontrol checks found practically no live larvae and no eggs. Surveys conducted in nearby stands indicate a local buildup on about 500 acres. During the spruce budworm aerial survey moderate-to-heavy defoliation by the jack-pine budworm was also detected on scattered areas throughout the Superior National Forest. No definite plans are being made to conduct chemical control for this insect on any Federal lands in 1960.

European Pine Shoot Moth--Low Temperature Reduces Populations

The European pine shoot moth (Rhyacionia buoliana) suffered a temporary but noticeable setback by the severe winter of 1958-59. A general decline in populations was noted throughout the range of this insect, and many plantations in Lower Michigan showed good recovery from shoot moth damage. The overwintering reductions caused cancellation of some of the chemical treatment originally proposed. Populations will build up again unless winter temperatures are low during the winter of 1959-60. Some of the recently developed insecticides show promise of giving good results at light dosages. But this insect, which is a serious threat to Christmas tree growers in many areas of Michigan and southeastern Wisconsin, still remains difficult to control.

Saratoga Spittlebug--
A Perennial Problem

The Saratoga spittlebug (Aphrophora saratogensis) remains a perennial problem in parts of northern Wisconsin and Michigan. Red pine plantations in northeastern Wisconsin and Michigan's Upper Peninsula are the most severely damaged, but damage is also sustained in Lower Michigan and over other portions of northern Wisconsin.

The State of Michigan aerially sprayed 526 acres in 1959 for control of this pest. The Wisconsin Conservation Department aerially sprayed 1,534 acres out of a total of 20,000 acres surveyed.

Chemical control was needed on 2,635 acres on 25 separate tracts of Federal land in Wisconsin and Michigan National Forests. Control was originally anticipated on about 3,000 acres, but June nymphal surveys indicated a population decline on some areas. Extremely hot, dry weather during early nymphal development may have contributed to this decline. Postcontrol surveys, conducted 3 to 5 days after spraying, showed satisfactory control. Nymphal surveys will be conducted in 1960 on 3,139 acres of Federal land to determine the acreage needing treatment.

White-Pine Weevil--
Treatment Results Are Variable

The ravages of the white-pine weevil (Pissodes strobi) reduce tree growth and quality and consequently restrict the planting of susceptible species on some areas. In some Michigan and Wisconsin plantations weeviling of 40 percent or more of the trees is not uncommon. The southern portion of the three Lake States is not seriously damaged. Control efforts for this pest have met with variable success.

The Michigan State Department of Conservation conducts control operations each year. In 1959 hand spraying was applied to 638 acres of jack pine plantations. They have also tried clipping the infested terminals. In their experience the most effective control is spraying in April, followed by hand clipping when infested terminals can be distinguished. Either DDT or a lindane-aroclor mixture seems to be effective.

An aerial treatment on a 54-acre jack pine plantation on the Ottawa National Forest, using a lindane-aroclor mixture, was not considered satisfactory. Hand spraying of an adjacent area using the same insecticide was also ineffective.

Larch Sawfly--Stands Declining

The larch sawfly (Pristiphora erichsonii) has remained in outbreak populations throughout many of the tamarack stands of the Lake States. Surveys indicate that tree mortality is common in some areas. Growth studies conducted by industrial foresters in Minnesota show that some stands contain trees that have had no net increment for the past 5 years.

Sampling in 1959 by Wisconsin Conservation Department entomologists revealed that of the 2,600 cocoons examined 73 percent were damaged by rodents, 10 percent were parasitized, and 17 percent were apparently undamaged.

No control has been contemplated by any agency to date. This decision is based on several factors. The scattered emergence of the larvae makes chemical control difficult. Tamarack is not often found in large blocks of commercial-size timber, so treatment may not be economically justifiable. In addition this species of tree is not in great demand at this time.

Pine Sawflies--Scattered Outbreaks

Of the several species of sawflies that are often serious pests in pine plantations, the red-headed pine sawfly is one of the more damaging in this region. In 1959, after surveying over 200 plantations for this pest, the Michigan Department of Conservation aerially sprayed 2,495 acres in a control operation. On some Federal plantations spraying was also done in conjunction with Saratoga spittlebug control operations. In addition scattered colonies that did not warrant aerial treatment were hand sprayed.

Previously most of the damage by the introduced pine sawfly has been confined to white pine. In 1959, however, it caused heavy defoliation on both white and jack pines in certain areas of Minnesota and Wisconsin. Jack pine on some Minnesota stands was quite heavily stripped, with only the current season's needles remaining.

Feeding by the red-pine sawfly and the white-pine sawfly was reported locally in Wisconsin. The European pine sawfly still caused concern and required control measures in Lower Michigan.

Pine Root Collar Weevil--Damage Increasing

The pine root collar weevil (Hylobius radicis) continues to attract attention as damage becomes more apparent. In 1959, increasing damage was reported in Douglas and Bayfield Counties, Wis., and in the Lower Peninsula of Michigan. In addition to roadside and windbreak trees, plantations are seriously affected. Although Scotch pine appears to be preferred, this pest readily attacks jack and red pines.

Forest Tent Caterpillar--Population Collapse

A general collapse of populations of the forest tent caterpillar (Malacosoma disstria) was noted in Wisconsin and Minnesota. No change in the endemic situation in Michigan was indicated.

Cold, driving rains following the emergence of the young larvae probably contributed greatly to the mortality. In addition the larvae emerged about 7 to 12 days before aspen leaves unfolded, and undoubtedly many larvae starved. No outbreaks are indicated in 1960.

White Grubs--Often Overlooked

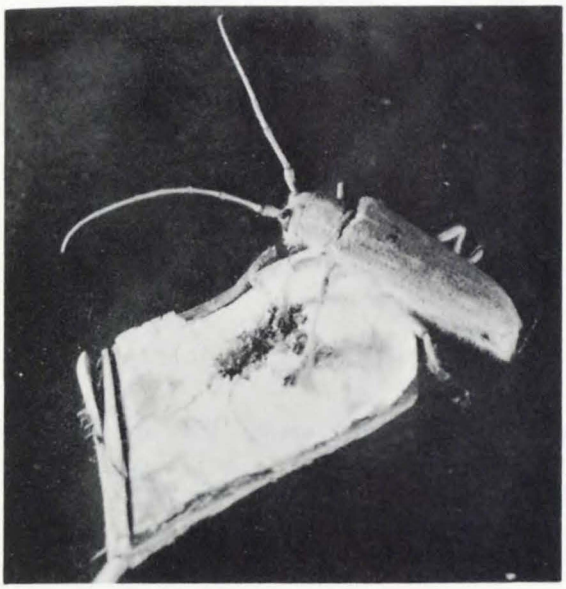
White grubs, which are the larvae of June beetles in the genus Phyllophaga and related genera, often cause great losses to recently established plantations. If the grubs are numerous they may completely destroy the root systems of the young trees. This damage is often overlooked, and death or stunting is frequently attributed to drought or other factors.

Over a 2-year period a loss of 40 percent of the trees on one area in Michigan was reported, compared to only 6 percent in a nearby area where aldrin was applied. Chemical treatment was applied to 1,414 acres on two Michigan State forests during 1959. No acreage figure is listed from other States, but many private owners are using some kind of chemical protection.

Zimmerman Pine Moth--
Kills New Shoots

The Zimmerman pine moth (Dioryctria zimmermani) has damaged jack, red, and Scotch pines in several areas of Wisconsin and Michigan. This damage is noticeable on 3,800 acres of pole-size red pine in Wexford County, Mich. The insect may kill young trees by killing the new shoots and mining the cambial region. In some areas this pest is a threat to Christmas tree production.

Poplar Borers--
Role as Vectors Unknown



The poplar borer (Saperda calcarata) has been suggested as a possible vector or incitant associated with Hypoxylon canker, Hypoxylon pruinatum. Although the exact importance of this relationship is not known, the borer is by itself an agent of destruction. Many trees weakened by larval tunnels eventually break. In addition the tunnels may harbor stains and decays that cause a reduction in wood quality.

Larvae tunnels of the poplar borer weaken trees and make them susceptible to wind damage. Top: Adult female and fresh egg niche. Bottom: Newly laid eggs as they appear on the underside of the bark.

A Pine Tip Moth-- First Reported in 1959

A pine tip moth (Rhyacionia adana) was first reported in Michigan during 1959. This insect had been reported previously in Ontario, Canada, and from its distribution in Michigan it has probably been in this State for several years.

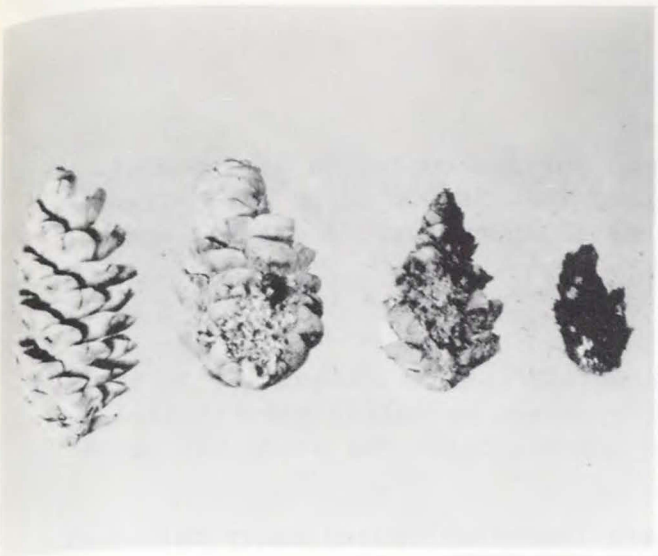
This pine tip moth attacks jack, red, and Scotch pines, but rarely damages trees over 3 feet in height. Characteristic damage includes the killing and browning of tips, similar to that caused by the European pine shoot moth. In a heavy infestation the trees become stunted and deformed. Typical damage was also noted in 1959 on the Chequamegon National Forest in Wisconsin, although no insects were found.

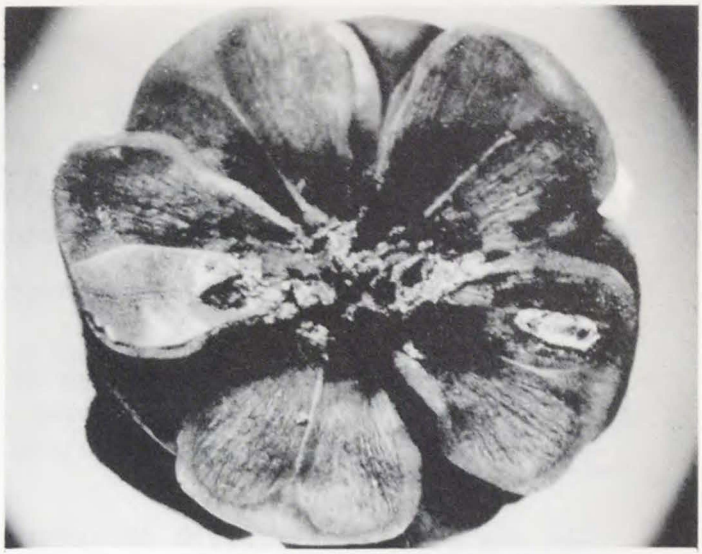
The life cycle of this pest has been determined by a Canadian investigator. The insect overwinters as a pupa. Because the adults emerge in mid-April and lay eggs, nurserymen must be on the alert for this pest lest they distribute egg-infested stock.

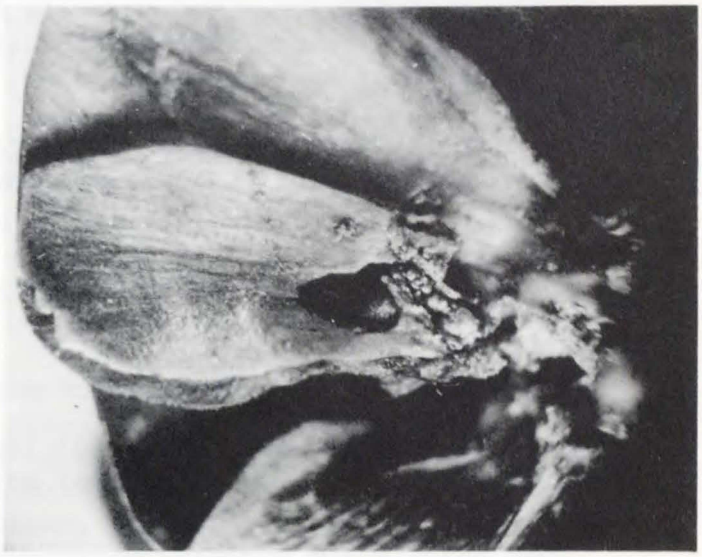
Cone and Seed Insects-- Study Under Way

Insect damage to white spruce cones was moderately heavy throughout the eastern portion of the Superior National Forest, Minn. Estimates of the percent of cones damaged varied from 8 to 57, averaging 32. Cone production was poor over most of the eastern half of the Forest. Observations were not made in the western section.

Studies directed toward the development of control measures were initiated by the Lake States Station in 1959. Present efforts are concentrated on determining the insect species involved and their life history and habits.







Seed and cone insects are an important factor in preventing natural regeneration of some tree species. Pictures show damage to white spruce cones. Above: An undamaged cone and others showing various degrees of damage. Top right: Enlargement of cone broken open to show damage. Right: Enlargement of a scale showing wing with seed eaten out.

Miscellaneous Hardwood Defoliators--Populations Decline in Wisconsin

Defoliation by two leafrollers (Sparganothis acerivorana and Acleris chalybeana) and the webworm (Tetralopha asperatella) was not prevalent or heavy in the maple blight areas of Wisconsin in 1959. Studies by the Station and the University of Wisconsin to determine the cause or causes of maple mortality are still in progress. Hand defoliation is being conducted by various investigators to simulate insect defoliation.

A large volume of oak, mostly in the red oak group, has died in one area of Michigan following 2 years of defoliation by the fruit tree leafroller (1956-57), coupled with a late spring frost in 1958 and drought conditions since 1955. The dead timber is located in Roscommon, Crawford, Oscoda,

and Ogemaw Counties. Aerial and ground surveys conducted by the Michigan Department of Conservation revealed that 29,000 acres were affected; the volume of dead oak was estimated at 43,200 cords. A salvage operation was recommended.

Walkingstick--New Outbreaks

The northern walkingstick (Diapheromera femorata) caused heavy defoliation on about 10,000 acres and moderate defoliation on 1,200 acres in Marinette County, Wis. In addition other scattered areas of defoliation were reported in Wisconsin and Minnesota.

An aerial DDT control program covering 350 acres of oak type was carried out with good effect on the Menominee Indian Reservation in central Wisconsin.

Gypsy Moth--

A report from the Michigan Plant Industry Division gave the following information concerning the gypsy moth.

"This last spring we treated approximately 20,000 acres at three different locations and, as in the past, a followup trapping program did not recover any moths in those areas that were treated.

"This past summer our trapping program uncovered six areas where moths were trapped. Generally the location of these traps was due west and southwest of Lansing. These two areas would comprise separate areas to be aerially treated and all totaled would amount to approximately 10,000 acres more or less."

The More Important Forest Disease Developments

Some of the important tree diseases in the Lake States are discussed briefly in the following pages. The discussion is limited to new diseases and those for which new and significant information was obtained.

Maple Blight Situation Shows Improvement

Maple blight is a term used to describe a condition first observed in Florence County, Wis., in the summer of 1957. The condition was characterized by the dying of hard maple of all sizes in randomly scattered patches throughout an area of about one township. During 1958 the same condition was discovered on two additional small areas in Iron County, but little change in the boundaries of the original area was noted.

In general, the maple blight situation improved during 1959. While some of the more severely affected trees died, many of those trees that had exhibited moderate to light symptoms appear to be recovering. There was no spread from the areas reported in previous years, but three additional small areas were found in Ashland County, Wis. The available evidence indicates that the damage on these new areas probably occurred at the same time as that discovered in Iron County in 1958.

Through the cooperation of Federal and State agencies and private organizations, much research effort has been expanded in attempting to determine the cause of maple blight. The Station has investigated environmental relationships that may relate to the problem. An intensive study has been installed to determine moisture requirements for hard maple trees in the area. Incorporated with the moisture requirement study will be an evaluation of the effects of defoliation. These are long-term studies on which results may not be available for some time.

The pathological and entomological aspects of maple blight are being investigated by the University of Wisconsin. Several investigators have conducted defoliation studies. These indicate that defoliating insects may be a major factor in causing maple blight. In addition, fungus isolations have been made from affected trees. Some of these isolates have been inoculated into healthy trees to determine if they will induce maple blight symptoms. Final evaluation of this work has not been made.

A hard maple that appears to be recovering from maple blight. The photo on the left was taken in July 1958. The photo on the right shows the same tree as it appeared in July 1959.

Oak Wilt Spread Somewhat Reduced

In 1959 the rate of establishment of new oak wilt infection centers was lower in all three of the Lake States. This information is based on annual surveys conducted to follow the pattern of infection in the area.

The Michigan survey is made by that State as a part of its oak wilt control program. This program, in effect since 1956, involves an aerial survey to detect new infection centers and recurrence of wilt in previously noted centers. Suspected areas noted from the air are checked on the ground, and infected trees are then treated so as to prevent spread to the surrounding timber.

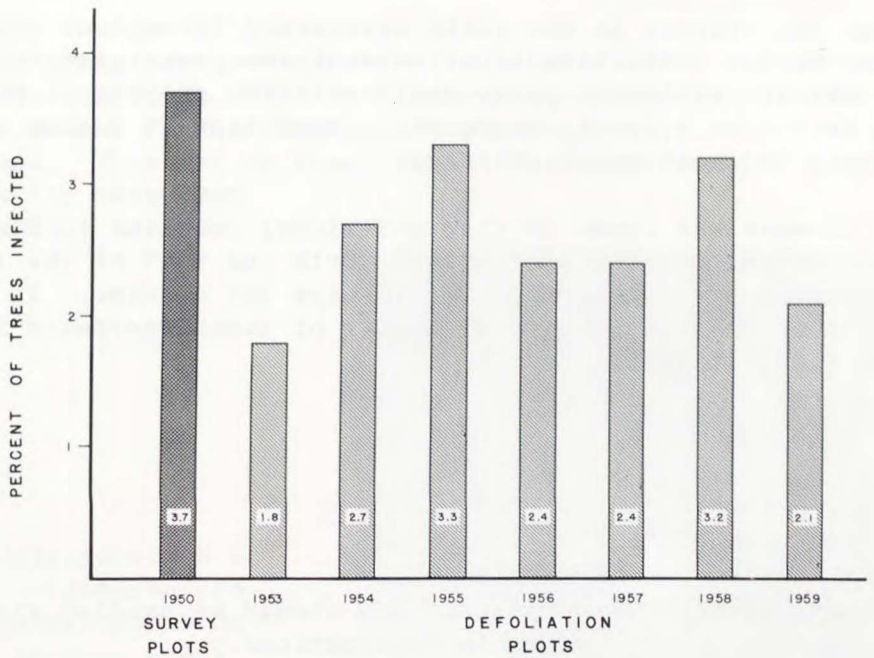
Since the initiation of these control measures in Michigan in 1956, the number of active oak wilt locations has declined annually. The first year 136 centers of infection involving 276 trees were found. In 1959 there were 51 centers involving 85 trees.

Oak wilt has been present in Minnesota and Wisconsin for a number of years. No Statewide control is practiced in either of those States. The rate of spread is followed by the Station through an annual survey in central Wisconsin and southeastern Minnesota. This survey, conducted since 1955, seeks to measure first, the local spread from existing centers, and secondly, the long-distance spread which results in the establishment of new centers.

During 1959 the results of both parts of this survey indicated a reduction in the spread of oak wilt. The spread from existing centers was slightly lower than in previous years, and the establishment rate of new centers was less than one-half as great as in any year since the survey was begun.

Prevalence of Hypoxylon Continues to Fluctuate

Continued remeasurement of permanent aspen plots in northern Minnesota indicates a definite fluctuation in the prevalence of Hypoxylon canker. These measurements are taken on plots selected so as to minimize the effects of age and geographic location. The 1959 results indicate an infection level on these plots that is lower than at any time since 1953.



Fluctuation in prevalence of Hypoxylon canker on aspen in northern Minnesota.

Nursery Root Rot Losses Are Continuing

Several nurseries in the region have suffered black spruce and red pine losses in recent years. These losses have been attributed to a root rot in both seedling and transplant beds. In 1959 another nursery reported similar losses. The cause of this condition has not been determined in any of these nurseries.

Attempts are being made to control these root rot losses. Various cultural and chemical treatments have been tried, but the most satisfactory control has resulted from the application of methyl bromide to the soil prior to planting. Large-scale treatments with this chemical are planned for at least one nursery during the next year.2/

Dutch Elm Disease Continues to Spread

Dutch elm disease is firmly established and appears to be intensifying in both Wisconsin and Michigan. It has not been reported in Minnesota, but it will probably appear in the future if it continues to spread in adjoining States as it has in recent years.

In Michigan the disease is now quite widespread throughout the southern part of the State. All attempts at control are restricted to municipalities that are following spray and sanitation programs. During 1959, as in the last 3 or 4 years, there was a reduction in number of diseased trees in many of these municipalities.

Dutch elm disease was found in five additional counties in Wisconsin this year. These counties are located north and west of the 10 southeastern counties previously reported to have the disease. In addition to the increase in area, the total number of trees increased from 1,832 in 1958 to 3,580 in 1959.

2/ Methyl bromide is very toxic and should be handled strictly in accordance with the manufacturer's instructions.

Stalactiform Rust Canker Found in Michigan

Stalactiform rust canker has now been found on jack pine in the Upper Peninsula of Michigan. This is a disease that is common on pine in the western United States. It was first reported east of the Great Plains in 1957 when it was discovered in Minnesota. The prevalence and damage caused by this disease have not been determined.

White Pine Blister Rust Cankers Very Abundant

During the year an unusually large number of white pine blister rust "flags" were noted on trees of all sizes in several areas. This condition is undoubtedly the result of a recent favorable infection year, the infections having now developed to the extent that many of the diseased branches have been girdled and killed by the fungus.

Decline and Mortality of South Dakota Elm Noted

Widespread dying and general deterioration of elm has occurred in southeastern South Dakota. This condition is quite serious in some areas. Galleries of the smaller European bark beetle were common in some of these trees. Thus far no fungi suspected to have caused this decline and mortality have been found in these trees.

General deterioration of elm was widespread in southeastern South Dakota. In some areas considerable mortality occurred.

Dead and Wilting Oaks Observed in South Dakota

Dead and wilting oak trees were observed in southeastern South Dakota during the summer of 1959. These trees were found in only one local area. The cause of this condition has not been determined.

Maple Dieback Still a Serious Threat to the Area

Maple dieback is a serious disease problem which may be confused with maple blight. Maple blight, however, is associated with hard maple trees of all sizes while maple dieback is limited only to larger trees. Both are a threat to the maple stands in this region.

In the past few years maple dieback has become common throughout much of the range of hard maple in the Lake States and has killed some trees. Because it seriously threatens one of our most valuable species, the Station has employed a pathologist whose major duty will be to investigate the factor or factors responsible for the disease.

SOME RECENT STATION PAPERS
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Fire Fuels in Red Pine Plantations, by Loyd LaMois, Sta. Paper 68, 19 pp., illus. 1958.

Snow Behavior in Forests of Northern Minnesota and its Management Implications, by Sidney Weitzman and Roger R. Bay. Sta. Paper 69, 18 pp., illus. 1959.

Growth of Swamp Conifers Following an Improvement Cut, by D. D. Skilling. Sta. Paper 71, 10 pp., illus. 1959.

Direct Seeding and Planting of Balsam Fir in Northern Wisconsin, by J. H. Stoeckeler and D. D. Skilling. Sta. Paper 72, 22 pp., illus. 1959.

Seed Production Areas in the Lake States: Guidelines for Their Establishment and Management, by Paul O. Rudolf. Sta. Paper 73, 16 pp., illus. 1959.

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Wood Use by Manufacturing Firms in Minneapolis and Saint Paul, by John R. Warner and Carl H. Tubbs. Sta. Paper 75, 30 pp., illus. 1959.

Effects of Forest Cover on Soil Freezing in Northern Lower Michigan, by W. D. Striffler. Sta. Paper 76, 16 pp., illus. 1959.

Influence of Ownership on Forestry in Small Woodlands in Central Wisconsin, by Charles F. Sutherland, Jr., and Carl H. Tubbs. Sta. Paper 77, 21 pp., illus. 1959.

Volume Tables for Aerial Timber Estimating in Northern Minnesota, by Gene Avery and Merle P. Meyer. Sta. Paper 78, 21 pp., illus. 1959.